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1. PURPOSE

The purpose of this analysis is to outline and recommend two standby generator systems. These systems shall provide power during a utility outage to critical Alcove #5's thermal test loads and to subsurface flow through ventilation loads. Critical loads that will be supported by these generator systems will be identified and evaluated. Additionally, other requirements from the Exploratory Studies Facilities Design Requirements (ESFDR) document will be evaluated. Finally, the standby generator systems will be integrated into the existing ESF subsurface distribution system.

The objective of this analysis is to provide design inputs for an efficient and reliable standby generator systems which will provide power for critical loads during a power outage; specifically, Alcove #5's thermal test loads and the subsurface flow through ventilation loads. Additionally, preliminary one-line diagrams will be developed using this analysis as a primary input.

2. QUALITY ASSURANCE

The activities associated with the items which are the subject of this design analysis have been evaluated in the Determination of Importance Evaluations BAB000000-01717-2200-00005 Rev 06 (Ref.5.2) and BAB000000-01717-2200-00106 Rev 02 (Ref. 5.12) and there are no DIE requirements specifically associated with the activities discussed herein. Hence the QA classification of this design analysis is "NONE." Therefore, no quality assurance controls apply to the output from this design such as drawings and specifications.

3. METHOD

The method used in this design analysis consists of identifying the standby electrical power requirements, and using standards for industrial power systems and commercially available equipment, outline new standby systems that can meet these requirements.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

4.1.1 The North Portal ESF Subsurface Distribution system interface is at the Subsurface Power Center located near the North Portal. (Ref. 5.8)

4.1.2 The South Portal ESF Subsurface Distribution system interface is an existing pad mounted liquid fill 750 KVA 12.48 KV to 480V resistive grounding system located near the South Portal. (Ref. 5.11)

4.1.3 The ESF lightning protection system consist of two lightning prevention systems providing protection to the North and South Portal areas. (Ref. 5.15 & 5.16)

4.1.4 The North and South Portal area has been designed to withstand the loads caused by a 100 year probable maximum flood local storm identified in the Reference Information Base, YMP/93-02. (Ref. 5.17 & 5.18)

4.2 CRITERIA

Criteria in this analysis were developed to respond to the ESFDR (Ref. 5.1) requirements. ESFDR requirements are cited for each criterion statement.

4.2.1 Standby power system shall be designed in accordance with applicable sections of Department of Energy (DOE) Order 6430.1A, and 29 Code of Federal Regulations (CFR) 1910 and 1926. (ESFDR 3.2.1.1.2.4.I, 3.2.1.2.4.C)

4.2.2 Standby power system shall provide and maintain power for critical test activities, ventilation, evacuation, fire control, back-up UPS, safety, operations, and security loads as required. (ESFDR 3.4.5.2.1.F, 3.4.5.2.1.H, 3.4.5.2.1.R, 3.4.5.2.1.S)

4.2.3 Standby power to the underground systems shall provide all necessary power to systems and subsystems that are required in the event of a power outage, based on safety or operational requirements for the operation of the ESF. (ESFDR 3.8.2.2.1.I)

4.2.4 Electrical standby power shall be provided to the ventilation system to retain operational function when primary power is lost. A reduced level of ventilation necessary to support critical activities is acceptable. (ESFDR 3.8.2.2.1.A)

4.2.5 The standby power system shall include generators, fuel supplies, necessary fuel piping, conduit and wire, cutouts, concrete work, and weatherproof enclosures. (ESFDR 3.4.5.2.1.T)

4.2.6 The standby power generators shall provide power to the underground operation following loss of primary power within the allowable delay time dictated in the safety analysis. (ESFDR 3.4.5.2.1.U)

4.2.7 The standby generator system shall be designed in compliance with all applicable requirements stipulated in the Air Quality Operation Permit AP 9611-0573. (ESFDR 3.4.5.2.1.Z)

4.2.8 The Standby Generator System shall be designed in compliance with all applicable requirements in the General Discharge Permit Application, issued by the Nevada Division of Environmental Protection. (ESFDR 3.4.5.2.1.AA)

4.2.9 The interconnection between the standby power and the main power distribution system shall allow the generating capacity of the standby system to be increased without modification of the interconnection. (ESFDR 3.4.5.2.1.J)

4.2.10 The minimum critical standby power shall provide a minimum excess capacity of 10 % margin over the predicted load. (ESFDR 3.4.5.2.1.L)

4.2.11 The standby power system shall allow for ESF operation on a three-shifts-per-day, seven-days-per-week throughout the ESF operational phases. (ESFDR 3.2.1.1.2.2.B)

4.2.12 Standby power system shall not unnecessarily restrict foot/vehicular traffic, and obstruct ventilation or cause health and safety concerns. (ESFDR 3.4.5.1.2.A, 3.8.2.1.2.B, 3.8.2.1.2.C)

4.2.13 Standby power system shall be designed for maintainable service life of at least 25 years. (ESFDR 3.2.1.2.2.A)

4.2.14 Surplus government equipment shall be considered for filling the requirements of the ESF facilities in accordance with appropriate procedures. (ESFDR 3.2.1.1.3.2.B)

4.2.15 All electrical power wiring must be kept physically separated from data and communication wiring to prevent induced interference. (ESFDR 3.4.5.2.1.D, 3.8.2.2.1.B, 3.8.2.2.1.P)

4.2.16 Standby power system shall have suitable switching and protection devices to prevent damage to the equipment in case of faults. (ESFDR 3.8.2.2.1.D)

4.2.17 Standby power system electrical equipment shall be designed to withstand and operate in an environment with sand and dust. (ESFDR 3.2.1.2.1.1.J, 3.2.1.2.1.2.B)

4.2.18 The ESF subsurface facilities and equipment shall be designed to withstand and operate in temperatures ranging from a low of -14 degree F to a high of 108 degree F. (ESFDR 3.2.1.2.1.1.F)

4.2.19 Standby power system electrical equipment shall be designed to withstand and operate in a relative humidity environment of 13 to 71%. (ESFDR 3.2.1.2.1.1.H, 3.2.1.2.1.2.D)

4.2.20 Standby power system shall be designed to withstand a seismic event. Temporary ESF subsurface installation shall conform to the requirements specified in the Uniform Building Code for UBC Zone 3. (ESFDR 3.2.1.2.1.1.B, Appendix A-A.1)

4.2.21 Standby power system shall be designed to withstand 75 mph (high winds) prevailing winds with maximum gusts up to 97 mph. (ESFDR 3.2.1.2.1.1.C)

4.2.22 Standby power system shall be designed with appropriate grounding to withstand and minimize the potential for damage due to a direct lightning strike. (ESFDR 3.2.1.2.1.1.D)

4.2.23 Standby power system shall be designed to withstand daily precipitation levels of 2.18 inches within 24 hour period. (ESFDR 3.2.1.2.1.1.E)

4.2.24 Standby power system shall be designed to withstand maximum loads caused by snow of 10 inches maximum loads caused by snow fall of 10 inches maximum in a 24 hour period. (ESFDR 3.2.1.2.1.1.G)

4.2.25 Standby power system shall be designed to withstand the loads caused by a 100 year probable maximum flood local storm identified in the Reference Information Base, YMP/93-02. (ESFDR 3.2.1.2.1.1.I)

4.2.26 To the extent practicable, all standby power system electrical equipment shall be standard commercial off-the-shelf items and replacement parts will be readily available to optimize life cycle supportability, procurement lead time, training requirements, and spares and repairs commonality. (ESFDR 3.2.1.1.3.2.A)

4.2.27 The standby power system shall provide surge protection and a grounding system to maximize personnel and equipment safety. (ESFDR 3.4.5.2.1.P, 3.8.2.2.1.F, 3.8.2.2.1.G)

4.2.28 Utility lines, steel supports, and other conducting structures supporting electrical systems, shall be electrically bonded to the subsurface electrical safety grounding network. (ESFDR 3.8.2.2.1.O)

4.2.29 The order of precedence for ESF requirements shall be (ESFDR 3.2.1.1.1.B.1):

- Federal Laws and Document
  - Laws, Statues, United States Codes, and Treaties
  - Codes of Federal Regulations and Executive orders (Including NRC Regulatory Guides and DOE Orders and Notices)
  - Other documents, orders, and directives
- State Laws and Standards
- Local Ordinances
- National and International Standards

4.3 ASSUMPTIONS

4.3.1 Alcove #5 has a network server used to transmit testing related data to the fiber optic network. Estimated load is 500 Watts at 120 VAC. (Used in Section 7.1.2.4)

4.3.2 Alcove #5 has two PC's with monitors that will be connected to the North Portal generator system. Estimated loads are 250 Watts for each PC and 200 watts for each monitor for a total estimated load of 900 Watts at 120 VAC. (Used in Section 7.1.2.5)

4.3.3 Alcove #5 has two mini DAS units. Estimated load for these units are 300 Volt-Amps each for a total of 600 Volt-Amps. (Used in Section 7.1.2.6)

4.3.4 Alcove #5 has power supplies, UPS's, 120 Volt receptacles and lighting loads that will be connected to the North Portal generator system. Estimated load for the miscellaneous equipment is 5 KW. (Used in Section 7.1.2.7)

4.3.5 Walker Shack estimated load is 3000 Watts for lighting and 720 Watts for receptacles. Lighting loads includes the walker shack lights and the portal entrance lighting. Receptacle loads include power for battery recharger, radio communications, and other miscellaneous loads. (Used in Section 7.1.1.2)

4.3.6 Typical power factor for computer/data processing equipment is approximately 90 percent. (Used Throughout)

4.3.7 The ventilation fan for Alcove #5 has not been purchased; therefore, the electric characteristics of a Reliance Electric 75 HP ventilation fan motor will be used for this analysis. The characteristics of the Reliance Electric 75 HP motor are listed below: (Attachment III)(Used in Section 7.1.1.1)

Motor HP: 75
Motor Shaft KW: 56.0
Motor Voltage Rating: 460V
Motor is High Inertia
Motor: RKW: 58.90
Code Letter: G
Motor RKVA: 68.52
Run Power Factor: 86.5 %

Motor Phase: 3
Hz: 60
Motor LR-KVA: 431.83
Motor SKW: 172.73
Motor SKVA: 431.83
Load Factor: 100 %

4.4 CODES AND STANDARDS

4.4.1 Nation Fire Protection Association (NFPA)

NFPA 70	National Electrical Code (NEC), 1996
NFPA 110	Emergency and Standby Power Systems, 1996

4.4.2 Code of Federal Regulations (CFR)

CFR Title 29	Labor, Part 1910, Occupational Safety and Health Standards, 1997.
CFR Title 29	Labor, Part 1926, Safety and Health Regulations for Construction, 1997.

4.4.3 U.S. Department of Energy (DOE)

DOE Order 6430.1A	General Design Criteria, Applicable portions to Subsurface Power Distribution System, 4/6/86

4.4.4 Institute of Electrical and Electronics Engineers (IEEE)

IEEE-Std.	IEEE Recommended Practice for Emergency and Standby Power System for Industrial and Commercial Applications, 1995

5. REFERENCES

5.1 *Exploratory Studies Facility Design Requirements (ESFDR),* U.S. Department of Energy, YMP/CM-0019, Rev. 02, 04/22/96

5.2 CRWMS M&O, *Determination of Importance Evaluation for Subsurface Exploratory Studies Facility*, DI# BAB000000-01717-2200-00005 Rev. 06

5.3 Not Used

5.4 *Electric Power Generation Designer (EPG) Program,* Caterpillar Inc., Version 2.3

5.5 CRWMS M&O Analysis, *Heated Drift Ventilation System Design Analysis*, DI# BABFAD000-01717-0200-00008 Rev. 00

5.6 CRWMS M&O Analysis, *ESF Flow-Through Ventilation Analysis,* DI# BABFAD000-01717-0200-00006 REV 01

5.7 Catalog, *Allen-Bradley Automation Systems,* Rockwell Automation Allen-Bradley Publication B112-March 1997

5.8 CRWMS M&O Drawing, *Subsurface Main & North Portal Swgr Single Line Diagram,* DI# BABFAA000-01717-2100-44000 REV 01

5.9 CRWMS M&O Drawing, *ESF Flow Through Ventilation Monitoring Plan & Details,* DI# BABFAA000-01717-2100-44124 REV 00

5.10 CRWMS M&O Drawing, *ESF Flow Through Ventilation Electrical Layout,* DI# BABFAA000-01717-2100-44121 REV 01

5.11 CRWMS M&O Drawing, *ESF Flow Through Ventilation One-Line Diagram,* DI# BABFAA000-01717-2100-44120 REV 01

5.12 CRWMS M&O, *Determination of Importance Evaluation for the Surface Exploratory Studies Facility*, DI# BAB000000-01717-2200-00106 Rev 02

5.13 CRWMS M&O Interoffice Correspondence, *Advance Procurement of Standby Generators,* DI# LV.ESSD.LJF.01/98-008

5.14 CRWMS M&O Calculation, *Concrete Pad Design for ESF Subsurface Standby* Generators, DI# BABFAA000-01717-0210-00001 Rev 00

5.15 CRWMS M&O Drawing, *North Portal Lightning Protection Plan,* DI# BABBDA000-01717-2100-24043 REV 00

5.16 CRWMS M&O Drawing, *South Portal Lightning Protection Plan,* DI# BABBDA000-01717-2100-24046 REV 00

5.17 CRWMS M&O Drawing, *North Portal Pad Finished Grading and Paving Plan,* DI# BABB00000-01717-2100-20022 REV 02

5.18 CRWMS M&O Drawing, *South Portal Pad and Box-Cut Site and Grading Plan,* DI# BAB000000-01717-2100-20210 REV 00

6. USE OF COMPUTER SOFTWARE

6.1 The computer used on this analysis was an IBM Compatible Pentium Pro 266 MHZ.

6.2 EPG program is the computer software used in this analysis (Ref 5.4).

6.3 The computer software used in this analysis is appropriate for this application.

7. DESIGN ANALYSIS

It is essential to have a reliable standby generator system to support the critical activities. Critical activities such as Alcove #5's thermal test and flow through ventilation will be backed-up by two diesel generator systems. The loss of critical characterization data and ventilation due to a power outage is considered unacceptable.

Suppling electric power with diesel generators, bypass panels, and an integrated control system can be costly. Therefore, a common-sense approach will be used to determine the standby generation system. The goals are:

1. To avoid loss of characterization data or prevent damaging equipment from heat generated from the thermal test being conducted in Alcove #5.

2. Maintaining and controlling the flow of air in the main drift to assure safety of personnel and exhausting the heat generated in Alcove #5.

Therefore, this analysis will identify critical loads and evaluate them with respect to quantity, type, or duration. Furthermore, two viable standby generator systems will be presented, one at the North Portal and the second at the South Portal. These standby generator systems shall satisfy the ESF requirements and be integrated into the existing ESF subsurface distribution system.

7.1 CRITICAL LOADS

This section will evaluate the critical loads that the standby generator systems will supply. These critical loads shall be used as the basis for sizing the generator system equipment to include diesel generators, transfer panel, distribution panelboards, and wiring.

7.1.1 Ventilation Fans

7.1.1.1 Alcove #5 Vent Fans

Alcove #5 has three ventilation fans with across the line starters. Two 75 HP ventilation fans are used to cool Alcove #5 to a level where equipment can operate without damage. The equipment is used to heat up the repository block and record thermal, mechanical, hydrological and chemical characteristics of the repository block. The gathering and storing of characterization data is considered critical to the Yucca Mountain project. The third fan is also a 75 HP ventilation fan. This fan is used whenever flow through ventilation in the main drift is down and will exhaust the heat to the main drift 66 inch ventilation duct. (Ref. 5.5)

For equipment and data protection, only the primary cooling fans are needed and not the standby fan. Therefore, only two of the three ventilation fans will be backed-up by the standby generating systems. Additionally, to minimize large inrush currents for generator starting, the ventilation fans starting times need to be staggered (Stepped Start).

Location: Preliminary design shows that these fan units will be located just outside Alcove #5 in the main drift. (Ref. 5.5)

Because of the close proximity to the North Portal, these ventilation fans shall be connected to the North Portal Generator System.

Typical generator sizing data for a 75 HP ventilation motors (Attachment III)(Assumption 4.3.7):

Motor HP: 75	Quantity: 3
Motor Shaft KW: 56.0	Motor Phase: 3
Motor Voltage Rating: 460V	Hz: 60
Motor is High Inertia	Motor LR-KVA: 431.83
Motor: RKW: 58.90	Motor SKW: 172.73
Code Letter: G	Motor SKVA: 431.83
Motor RKVA: 68.52	Load Factor: 100 %
Starting Power Factor: 40 %	Run Power Factor: 86.5 %
Motor Starting Method: Across the Line	

7.1.1.2 Flow Through Ventilation Fan

The flow through ventilation fan is a 250 HP ventilation fan with across the line starter. The fan's primary purpose is to provide flow through ventilation for underground personnel, tunnel excavation and to exhaust the heat generated in Alcove #5. (Ref. 5.6)

Location: The fan unit will be located in the South Ramp near the South Portal. (Ref. 5.6)

Because of the close proximity to the South Portal, the ventilation fan shall be connected to the South Portal Generator System.

Generator sizing data for a 250 HP ventilation fan (Attachment III):

Motor HP: 250	Quantity: 1
Motor Shaft KW: 186.5	Motor Phase: 3
Motor Voltage: 480V	Hz: 60
Motor is High Inertia	Motor LR-KVA: 1454.06
Motor: RKW: 193.81	Motor SKW: 348.97
Code Letter: G	Motor SKVA: 1454.06
Motor RKVA: 221.49	Load Factor: 100 %
Start Power Factor: 24 %	Run Power Factor: 87.5 %
Motor Starting Method: Across the Line	

7.1.2 Alcove #5 Testing Loads

Critical loads directly associated with Alcove #5's large scale, long duration thermal test activities will be backed-up with standby power. Critical loads such as Data Acquisition System (DAS) units, air conditioning units for equipment, network servers, PC's, miscellaneous network equipment, mini DAS units, power supplies, etc. will be connected to the standby generator system at the North Portal.

7.1.2.1 DAS Units

There are a total of six DAS units. The DAS units monitor, record, and provide power for the thermal test instrumentation. These DAS units come with an on-line UPS unit to provide backup power and isolate the DAS units from power fluctuations. The DAS units power requirements exclusive of the cooling units is 5 KW at 208 V. (Ref. 5.13)

7.1.2.2 DAS Air Conditioning Unit

The DAS air conditioning equipment will be connected to the standby generator system at the North Portal. The load requirement for the DAS air conditioning equipment is 21.6 KW at 208 VAC. (Attachment III)

7.1.2.3 Fire Detection Unit

Alcove #5 has a fire protection unit that will be connected to the North Portal generator system. Rated load is 2.6 Amps at 120 VAC. (Attachment III)

7.1.2.4 Network Server

Alcove #5 has a network server that will be connected to the North Portal generator system. Estimated load is 500 Watts at 120 VAC. (Assumption 4.3.1)

7.1.2.5 PC's

Alcove #5 has two PC's with monitors that will be connected to the North Portal generator system. Each PC is estimated at 250 Watts for the PC and 200 watts for each monitor for a total of 900 Watts at 120 VAC. (Assumption 4.3.2)

7.1.2.6 Mini DAS Units

Alcove #5 has two mini DAS units that will be connected to the North Portal generator system. Estimated load for these units are 300 Volt-Amps each for a total of 600 Volt-Amps. (Assumption 4.3.3)

7.1.2.7 Alcove #5 Miscellaneous Equipment

Alcove #5 has power supplies, UPS's, 120 receptacles and lighting loads that will be connected to the North Portal generator system. Estimated load for the miscellaneous equipment is approximately 5 KW. (Assumption 4.3.4)

7.1.2.8 Alcove #5 AOD Office UPS

Alcove #5 has an office with a primary UPS system that supplies power to test equipment. Load requirement for the UPS system is 6 KW at 208 Volts. (Ref. 5.13)

7.1.2.9 Alcove # 5 AOD Office AC Unit

Alcove #5 test equipment needs to be protected from heat damage from the thermal test. Load requirement for the air conditioning of the office area is 2 KW at 208 Volts. (Ref. 5.13)

7.1.2.10 Alcove #5 CRTS Niche

Test activities in the CRTS Niche will need backup power. Load requirement for this activity is 2.5 KW at 208 Volts. (Ref. 5.13)

7.1.3 North Portal Loads

7.1.3.1 Ventilation Programmed Logic Controller (PLC) System

A PLC control system located at the walker shack will be used to control the ventilation fans and report generator status. Primarily, the PLC control system will monitor and control ventilation for the Alcove #5 thermal test area and the flow through ventilation at the South Portal. Additionally, the PLC system will monitor generator status such as low fuel, fail to start, weak battery, etc.. Loads for the PLC system are listed below: (Ref 5.7 and 5.9)

ITEM	LOAD
UPS	600 Watts
PLC Rack	148 Watts
Display Panel	720 Watts
TOTAL	1468 Watts

7.1.3.2 Walker Shack Miscellaneous Loads

Operation needs dictate that minimal lighting and receptacle loads are required for the manned station at the Walker Shack. The walker has the responsibility to report emergencies and problems in the subsurface areas to include ventilation failure at Alcove #5 and the South Portal, and generators' failures and fuel status at the South and North Portal. The electrical distribution at the walker shack provides lighting at the North Portal entrance that may be needed for emergency egress. Estimated load is 3000 Watts for lighting and 720 watts for receptacles. (Assumption 4.3.5)

7.1.3.3 DAS Trailer

The DAS trailer is used to provide interface to the surface for monitoring and controlling of test activities in the subsurface area to include Alcove's #5 thermal test. The DAS trailer can also be used as an assembly point for the mine rescue team during an emergency. Load for this trailer is estimated at 25 KVA. (Attachment III)

7.1.3.4 Future Test Loads

The testing community would like 10 KW of standby generation for future loads. (Attachment III)

7.1.4 South Portal Miscellaneous Loads

The access trailer, lights around the bulkhead doors and lights at the South Portal entrance which may be needed for egress during an emergency will be connected to the South Portal standby generator system. Estimated load is 60 KW at 480 VAC. (Ref. 5.10)

7.1.5 Critical Load Summary

Shown in the following tables is the summary of the critical loads with their running and starting KW and KVA.

NORTH PORTAL CRITICAL LOAD SUMMARY					
STARTING STEP	LOADS	RUNNING		STARTING	
		KW	KVA	KW	KVA
1	Alcove 5 Vent 75 Hp Fan #1	58.90	68.52	172.73	431.83
1	Alcove 5 DAS Units	5.00	5.56	5.00	5.56
1	Alcove 5 DAS Units AC	21.60	24.00	41.75	63.97
1	Alcove 5 Fire Detection	0.31	0.31	0.31	0.31
1	Alcove 5 Network Server	0.50	0.56	0.50	0.56
1	Alcove 5 PC's	0.90	1.00	0.90	1.00
1	Alcove 5 mini DAS Units	0.50	0.60	0.50	0.60
1	Alcove 5 Misc. Loads	5.00	5.56	5.00	5.56
1	Alcove 5 Office UPS	6.00	6.67	6.00	6.67
1	Alcove 5 Office AC	2.00	2.22	2.00	2.22
1	Alcove 5 Crts Niche	2.50	2.78	2.50	2.78
1	North Portal PLC	1.47	1.63	1.47	1.63
1	North Portal Wk Shack	3.72	3.72	3.72	3.72
1	North Portal DAS Trailer	1.25	25.00	21.25	25.00
1	Testing Misc. Loads	10.00	11.76	10.00	11.76
1	Sub Total	139.65	159.88	273.63	563.16
1	10 % Margin	13.97	15.99	27.36	56.32
1	**TOTAL STEP 1**	**153.62**	**175.87**	**300.99**	**619.48**
2	Alcove 5 Second 75 Hp Fan	58.90	68.52	172.73	431.83
2	10 % Margin	5.89	6.85	17.27	43.18
2	**TOTAL STEP 2**	**64.79**	**75.37**	**190.00**	**475.01**
	TOTAL	**218.41**	**251.24**	**N/A**	**N/A**

SOUTH PORTAL CRITICAL LOAD SUMMARY					
START-IN STEP	LOADS	RUNNING		STARTING	
		KW	KVA	KW	KVA
1	Flow Thru Vent Fan	193.81	221.49	348.97	1454.06
1	Misc S. Portal Loads	60.00	66.67	60.00	66.67
1	10 % Margin	25.38	28.82	40.90	152.07
1	TOTAL STEP 1	279.19	316.97	449.87	1672.80
	No Step 2				
	TOTAL	279.19	316.97	449.87	1672.80

7.2 ESF REQUIREMENTS

Besides the above load requirements, the ESFDR has specific design requirements that need addressing. These requirements are addressed on an individual basis with its appropriate response directly afterwards.

Requirement: Standby power system shall be designed in accordance with applicable sections of Department of Energy (DOE) Order 6430.1A, and 29 Code of Federal Regulations (CFR) 1910 and 1926. (Ref. 4.2.1)

Response: A review of the above DOE order and CFRs uncovered a myriad of code requirements that are directly applicable to the standby generator systems. Subject areas like wiring, raceways, emergency power systems, grounding, etc. are addressed.

Additionally, DOE order 6430.1A instructs the designer to use additional codes and standards in the design; specifically, NFPA 110, NFPA 70, and IEEE 446.

The following documents/sections as a minimum needs to be incorporated in Standby generator systems final design:

- NFPA 70 Chapters 1, 2, 3, 4, 6, 7 , 8 and 9
- NFPA 110 Chapters 1, 2, 3, 4, 5 and 6
- IEEE Std. 446
- DOE Order 6430.1A Division 16
- 29 CFR 1910 Subpart “S”
- 29 CFR 1926 Subpart “K” and “S” (For Construction Areas)

The order of precedence for conflicting requirements of the above documents shall be as listed in the ESFDR paragraph 3.2.1.1.1.B (Ref. 4.2.29).

Requirement: Standby power system shall provide and maintain power for critical test activities, ventilation, back-up UPS, safety, operations, and security loads as required. (Ref. 4.2.2)

Standby power to the underground systems shall provide all necessary power to systems and subsystems that are required in the event of a power outage, based on safety or operational requirements for the operation of the ESF. (Ref. 4.2.3)

Response: Critical loads for Alcove #5, flow through ventilation, UPS, safety, operations, and fire protection has been identified. The identified loads shall be connected to the standby generation system.

Requirement: Electrical standby power shall be provided to the ventilation system to retain operational function when primary power is lost. A reduced level of ventilation necessary to support critical activities is acceptable. (Ref. 4.2.4)

Response: Alcove #5 and flow through ventilation fans are the only fans classified as critical for ESF operations to warrant connection to the standby power system. All other fan's operations do not warranted backup power.

Requirement: The standby power system shall include generators, fuel supplies, necessary fuel piping, conduit and wire, cutouts, concrete work, and weatherproof enclosures. (Ref. 4.2.5)

Response: The final design of the generator system shall include generators, fuel supplies, necessary fuel piping, conduit and wire, cutouts, concrete work, and weatherproof enclosures.

Requirement: The standby power generators shall provide power to the underground operation following loss of power of primary power within the allowable delay time dictated in the safety analysis. (Ref. 4.2.6)

Response: A safety analysis has not been accomplished that addresses allowable delay times for standby generators. M&O System Engineering is aware of this requirement.

Commercially available generators are built to comply with NFPA 110 requirements for an emergency power source. These generators have a startup time of less than 10 seconds. Most transfer panels have time delays for generator startup of 0 to 15 seconds with a transfer to generator delay of 0 to 120 seconds. A time delay device can be easily added if the safety analysis determines a time delay greater than the capability of the transfer panel is required.

Requirement: The standby generator system shall be designed in compliance with all applicable requirements stipulated in the Air Quality Operation Permit AP 9611-0573. (Ref. 4.2.7)

The Standby Generator System shall be designed in compliance with all applicable requirements in the General Discharge Permit Application, issued by the Nevada Division of Environmental Protection. (Ref. 4.2.8)

Response: M&O Environmental Department was informed on the addition of these generators to the Yucca Mountain project and the necessary actions will be taken to update these permits.

Requirement: The interconnection between the standby power and the main power distribution system shall allow the generating capacity of the standby system to be increased without modification of the interconnection. (Ref. 4.2.9)

Response: Because the South and North Portal Generator systems are being designed and constructed for two specific purposes; this being, support critical Alcove # 5 test activities and flow through ventilation, there will be very limited capacity to accommodate an increase in generating capacity for other endeavors. Increasing the generator capacity will increase the size of the equipment necessary to deliver the increased power. Equipment such as feeders, transfer panels, distribution panels, fuel system, etc. will also need increasing.

Requirement: The minimum critical standby power shall provide a minimum excess capacity of 10 % margin over the predicted load. (Ref. 4.2.10)

Response: A minimum 10% excess capacity margin will be incorporated in the standby generator systems design.

Requirement: The standby power system shall allow for ESF operation on a three-shifts-per-day seven-days-per-week throughout the ESF operational phases. (Ref. 4.2.11)

Response: To ensure that the generator system operates when it is needed, a preventive maintenance program should be initiated by the operations group. The goal of a preventive maintenance program is to ensure that the standby systems are in optimum operating condition. Preventive maintenance consists of inspection, testing, cleaning, drying, monitoring, adjusting and minor repairs of the standby equipment. Once, the generator is running and because of the remoteness of the Yucca Mountain construction site, monitoring of the fuel level is critical. Standard commercial generator sub-base tanks are sized for 24 hour operations with Low Fuel level alarm at 1/4 tank or 6 hours. Six hours may not be enough time to call for same day fuel service from Las Vegas or Mercury. Setting the low level fuel alarm to ½ tank gives Yucca Mountain operation a minimum of 12 hours before the generators run out of fuel. This should be sufficient time to notify the proper personnel to call the fuel company, allow for delivery time to the Yucca Mountain site, and refuel the generators.

Requirement: Standby power system shall not unnecessarily restrict foot/vehicular traffic, and obstruct ventilation or cause health and safety concerns. (Ref. 4.2.12)

Response: The standby power system shall not restrict foot/vehicular traffic, and obstruct ventilation or cause health and safety concerns.

Requirement: Standby power system shall be designed for maintainable service life of at least 25 years. (Ref. 4.2.13)

To the extent practicable, all standby power system electrical equipment shall be standard commercial off-the-shelf items and replacement parts will be readily available to optimize life cycle supportability, procurement lead time, training requirements, and spares and repairs commonality. (Ref. 4.2.26)

Response: The standby power system will be standard commercially available industrial grade electrical equipment with a proven record of reliability, durability and safety. This equipment is built in accordance with NEMA standards for industrial equipments. Additionally, the equipment will be installed in areas where maintenance can be easily performed. In this way, any breakdown can be repaired quickly causing only a minor inconvenience.

Requirement: Surplus government equipment shall be considered for filling the requirements of the ESF facilities in accordance with appropriate procedures. (Ref. 4.2.14)

Response: Every effort will be made to find suitable equipment for standby power system from the Yucca Mountain project to save valuable resource and funds. If suitable surplus equipment is available, it should be identified on the design drawings for installation.

Requirement: All electrical power wiring must be kept physically separated from data and communication wiring to prevent induced interference. (Ref. 4.2.15)

Response: IEEE Std. 518 has minimum distance recommendations for the separation of data and communication wiring from power wiring. These minimum distance recommendations do not cause any foreseeable installation difficulties and therefore, they will be applied to the standby power system.

Requirement: Standby power system shall have suitable switching and protection devices to prevent damage to the equipment in case of faults. (Ref. 4.2.16)

The standby power system shall provide surge protection and a grounding system to maximize personnel and equipment safety. (Ref. 4.2.27)

Utility lines, steel supports, and other conducting structures supporting electrical systems, shall be electrically bonded to the subsurface electrical safety grounding network. (Ref. 4.2.28)

Response: The standby power system will have switching, protection, surge protection grounding, and bonding in accordance with 29 CFR 1910, NFPA 70 and 110 codes, and IEEE 442 standard.

Requirement: Standby power system electrical equipment shall be designed to withstand and operate in an environment with sand and dust. (Ref. 4.2.17)

The ESF subsurface facilities and equipment shall be designed to withstand and operate in temperatures ranging from a low of -14 degree F to a high of 108 degree F. (Ref. 4.2.18)

Standby power system electrical equipment shall be designed to withstand and operate in a relative humidity environment of 13 to 71%. (Ref. 4.2.19)

Standby power system shall be designed to withstand a seismic event. Temporary ESF subsurface installation shall conform to the requirements specified in the Uniform Building Code for UBC Zone 3. (Ref. 4.2.20)

Standby power system shall be designed to withstand 75 mph (high winds) prevailing winds with maximum gusts up to 97 mph. (Ref. 4.2.21)

Standby power system shall be designed to withstand daily precipitation levels of 2.18 inches within 24 hour period. (Ref. 4.2.22)

Standby power system shall be designed to withstand maximum loads caused by snow of 10 inches maximum loads caused by snow fall of 10 inches maximum in a 24 hour period. (Ref. 4.2.24)

Response: The standby power system shall incorporate the following environmental conditions.

Seismic Condition: UBC Zone 3 (Ref. 5.14)
Equipment shall withstand and operate
- -sand and wind blown dust
- -temperatures ranging from -14 °F to a high of 108 °F
- -relative humidity environment of 13 to 71%
- -75 mph prevailing winds with maximum gusts up to 97 mph
- -daily precipitation levels of 2.18 inches within 24 hour period
- -10 inches maximum snow fall in a 24 hour period

Requirement: Standby power system shall be designed with appropriate grounding to withstand

and minimize the potential for damage due to a direct lightning strike. (Ref. 4.2.22)

Response: The standby power system generators, transfer panels, conduits, and cables are protected by an existing lightning protection system located at the North and South (Section 4.1.3).

Requirement: Standby power system shall be designed to withstand the loads caused by a 100 year probable maximum flood local storm identified in the *Reference Information Base*, YMP/93-02. (Ref. 4.2.25)

Response: The generators' concrete pads will elevate the generator equipment at least 4 inches above grade to shed rain water to the existing graded site which has been designed to withstand the loads of a 100 year probable maximum local storm identified in the *Reference Information Base*, YMP/93-02. (Section 4.1.4).

7.3 STANDBY GENERATOR SET

A number of factors are used to correctly size a generator set. Startup of the critical loads will place severe demands on the generator (s). Demands such as ventilation fan startup will causes a large inrush current resulting in voltage and frequency dip in the electrical system. Motor starters, contactors, and relays are sensitive to voltage dip. As a guide, a voltage dip of 60 to 70% of rated voltage for 0.5 second will denergize many of these devices. Derating factors for temperature and elevation should be used. IEEE standard 446 (Ref. 5.3) outlines many of these factors and recommended guidelines for proper generator installation. Listed below are some of their recommendations:

Voltage Regulation, Steady State: ± 5% (Page 74)
Frequency Regulation: ± 0.5 to 0.25 % for isochronous governor (Page 110)
Generator Heaters for starting 10 seconds (Page 101 and 111)
Derating Factors: Elevation: 4 % per 1000 Ft above 3000 Ft Elevation
Temperature: 1% for each 10 °F above 60 °F (Page 103)
Voltage Dip on Starting: 30 % (Page 74)
Battery Charger (Page 111)
Battery Powered Starters (Page 111)
Radiator Cooling (Page 111)
Generator Protection: Short Circuit & Ground Fault (Page 171 and 186)

7.3.1 North Portal Generator Set

The input parameters used for the Caterpillar's EPG generator sizing program are listed below:

Voltage Dip Maximum: 30 %
Temperature Maximum: 110 Degree F
Elevation Maximum: 3700 Feet

Alternator Temperature Rise: 125 Degree C
Generator First Step Starting:

Alcove 5 Vent Fan #1	Alcove 5 Vent Fan #2	Alcove 5 DAS Units
Alcove 5 DAS Units AC	Alcove 5 Fire Detection	Alcove 5 Network Server
Alcove 5 PC's	Alcove 5 mini DAS Units	Alcove 5 Misc. Loads North
North Portal PLC	North Portal Misc. Loads	North Portal DAS Trailer
Testing Misc. Loads		

Second Step (At least 10 seconds after the first step): Standby Fan Unit If Necessary

Attachment I, North Portal Generator Sizing Reports, using Caterpillar's generator sizing program shows that 250 KW generators (minimum) will be needed. On initial startup, these generators will keep the voltage drop to below 30 % and the frequency dip to below 5 percent. After initial startup, a standard standby generator set will have the following running characteristics:

Voltage Regulation: No load to full Load within ±0.5 %
Frequency Regulation: Isochronous under varying loads from no load to 100% load
Random Frequency Variation: Will not exceed ± 0.25% of it mean value for constant loads from no load to full load
AC Waveform Total Harmonic Distortion: Less the 5% total no load to full linear load, and less than 3% for any single harmonic

Two generators will be needed at the North Portal. This is because the limited time period before equipment is damaged from elevated temperature in Alcove #5 is less than 15 minutes (Ref. 5.5). When backup power is needed, there is not enough time for troubleshooting or repairs if a single generator does not start. Because of the critical nature of the loads (valuable characterization data and equipment), it may be necessary that upon power disruption both generators should start. The first unit that comes on line will then pick up the critical loads. The second unit will be allowed to start and run for a minimum of approximately 10 minutes before shutting down (generators need a control shutdown period IAW manufacturer's recommendations). Another feasible scheme is to have the first generator start and after a few minutes (over-cranking failure from first generator control panel), start the second generator. These starting schemes are common in industrial applications (Ref. 5.3) and should be considered during design of the control system.

7.3.2 South Portal Generator Set

The input parameters used for the Caterpillar's EPG generator sizing program are listed below:

Voltage Dip Maximum: 30 %
Temperature Maximum: 110 Degree F
Elevation Maximum: 3700 Feet
Alternator Temperature Rise: 125 Degree C
Generator Starting Loads:

Flow Through Ventilation Fan
South Portal Misc. Loads

Attachment II, South Generator Sizing Report, shows that a 500 KW generator will be needed. On initial startup, a 500 KW generator (minimum) will keep the voltage drop to below 30 % and the frequency dip to 5 percent. After initial startup, a standard standby generator set will have the following running characteristics:

Voltage Regulation: No load to full Load within ±0.5 %
Frequency Regulation: Isochronous under varying loads from no load to 100% load
Random Frequency Variation: Will not exceed ± 0.25% of it mean value for constant loads from no load to full load
AC Waveform Total Harmonic Distortion: Less the 5% total no load to full linear load, and less than 3% for any single harmonic

Only one generator will be needed at the South Portal. Reason being, during a power outage a generator failure will cause the cessation of manned underground activities, but should not cause the equipment damage or injury to underground personnel. There is enough air in the subsurface drifts to allow personnel to evacuate safely to the surface. Additionally, there is only one flow through ventilation fan. A failure in this ventilation fan is more likely than a failure of both the utility and the generator.

A simple generator/transfer panel circuit should be used (See Figure 2). Upon interruption of utility power the transfer panel will initiate the start signal to the generators and transfer the loads to the generator and back upon restoration of utility power.

7.3.4 Common Generator Accessories

The following are typical generator features needed to integrate the standby generator into the existing ESF distribution system.

-Voltage: Three Phase 480/277 Volts 60 Hz
-AC Entrance Box
-Batteries
-Weather-Protective Enclosure
-Residential Grade Exhaust System Silencer
-Main Circuit Breaker
-Battery Charger, Equalizer, Float-type
-Spring Isolators
-Ground Fault Alarm
-Heavy Duty Air Cleaner
-Space Heater
-24 Hours (Minimum) Double Wall Sub-base Tank with Leak Detection System
-480 Volt Coolant Heater (Thermostat Controlled)
-Control Panel:
- **-Remote Starting Capabilities**
- **-Panel Lighting**
- **-Emergency Stop Switch**
- **-Run-Off-Auto Selector Switch**
- **-Digital Display**

-Generator Monitoring: Oil Temperature, Oil Pressure, Coolant Temperature, RPM, Running Hours
-Metering: Amp, Volt, Kilowatts & Frequency Meters
-Adjustments: Time Start Delay, Time Delay Stop, voltage, frequency, Automatic Voltage Regulation, and Governor Gain
-**Shutdown Functions (Failure)**: Low Oil Pressure, Over-speed, High Coolant Temperature, Fail to Crank, Over-crank
-AC Alternator Shutdowns: Low AC voltage, High AC voltage, Under-frequency, Over Current, Short Circuit, Emergency Stop
-Warning Functions (Pre-Shutdown): Low Oil Pressure, High Coolant Temperature, Over Current, Low Coolant Temperature, Low Fuel, Low DC Voltage, High DC voltage, Weak Battery
-Output Contacts (Customer Connections): Common Alarm Relays, Load shed Relay, Ready to Load Relay, NFPA 110 Alarm Contact, Three Auxiliary Run Relays

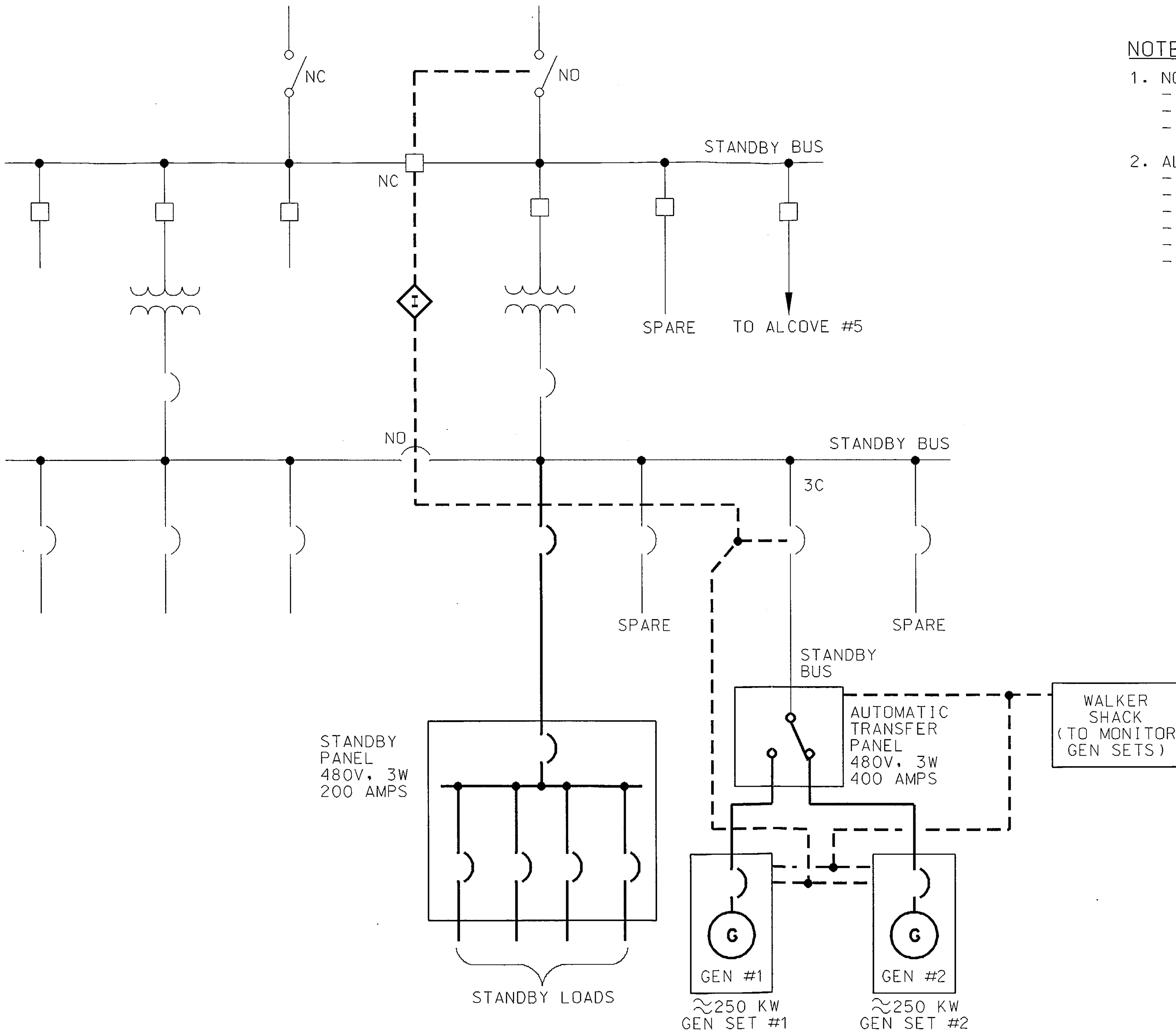
7.4 INTEGRATION INTO THE EXISTING ESF DISTRIBUTION SYSTEM

Two standby generator systems will be needed. The location of these standby systems will be outdoors at the North Portal and South Portal. To minimize losses the generators will be located as close to the largest load as reasonably possible. Additionally, by placing the generators outdoors environmental problems can be easily accommodated such as diesel exhaust, fuel storage, and noise. In both locations, integration into the existing ESF distribution will be at 480 Volts 3 Phase three wire system with neutral grounding. (Ref. 5.8 and 5.11)

7.4.1 North Portal Standby Generating System

The redundant generators will be installed at the North Portal replacing two leased 60 KW generators at the North Portal. Some wiring and interlocking between the existing subsurface switchgear and the temporary generator were accomplished. Additionally, the initial wiring of the temporary generators was designed to accommodate a 250 KW generator set. If the generators are larger than 250 KW, modification to the existing design will be required.

Figure 1 shows a one line diagram of the North Portal Standby generator system. It shows an addition of two new generators, one 400 amp transfer panel, interlocking, and a standby distribution panel to supply power to critical loads such as the Walker Shack and DAS Trailer.



NOTES:

1. NORTH PORTAL STANDBY LOADS INCLUDE:
   - VENTILATION CONTROL PLC
   - WALKER SHACK
   - TEST MONITOR TRAILER
2. ALCOVE #5 STANDBY LOADS INCLUDE:
   - DAS UNITS
   - FILE SERVERS
   - VENT FANS
   - PC'S
   - EQUIPMENT A/C
   - FIRE DETECTION

LEGEND:

- 15KV BREAKER
- 480V BREAKER
- AUTOMATIC TRANSFER PANEL
- GENERATOR
- 15KV SWITCH
- ELECTRICAL INTERLOCK
- EXISTING
- NEW
- CONTROL/COMM CABLE

FIGURE 1

NORTH PORTAL
STANDBY POWER SYSTEM
ONE LINE DIAGRAM

7.4.2 South Portal Standby Generating System

A generator will be installed at the South Portal to support flow through ventilation at the South Portal. A new generator concrete pad will be needed at the South Portal. Additionally, an Automated Transfer Switch (ATS) and an I/O rack will be needed to provide automatic transfer to the generator system upon a utility outage and monitor the generator set for low fuel, low battery, failure, etc., from the North Portal.

Figure 2 shows a one line diagram showing a generator, 1000 amp transfer panel, and I/O rack for remote communication.

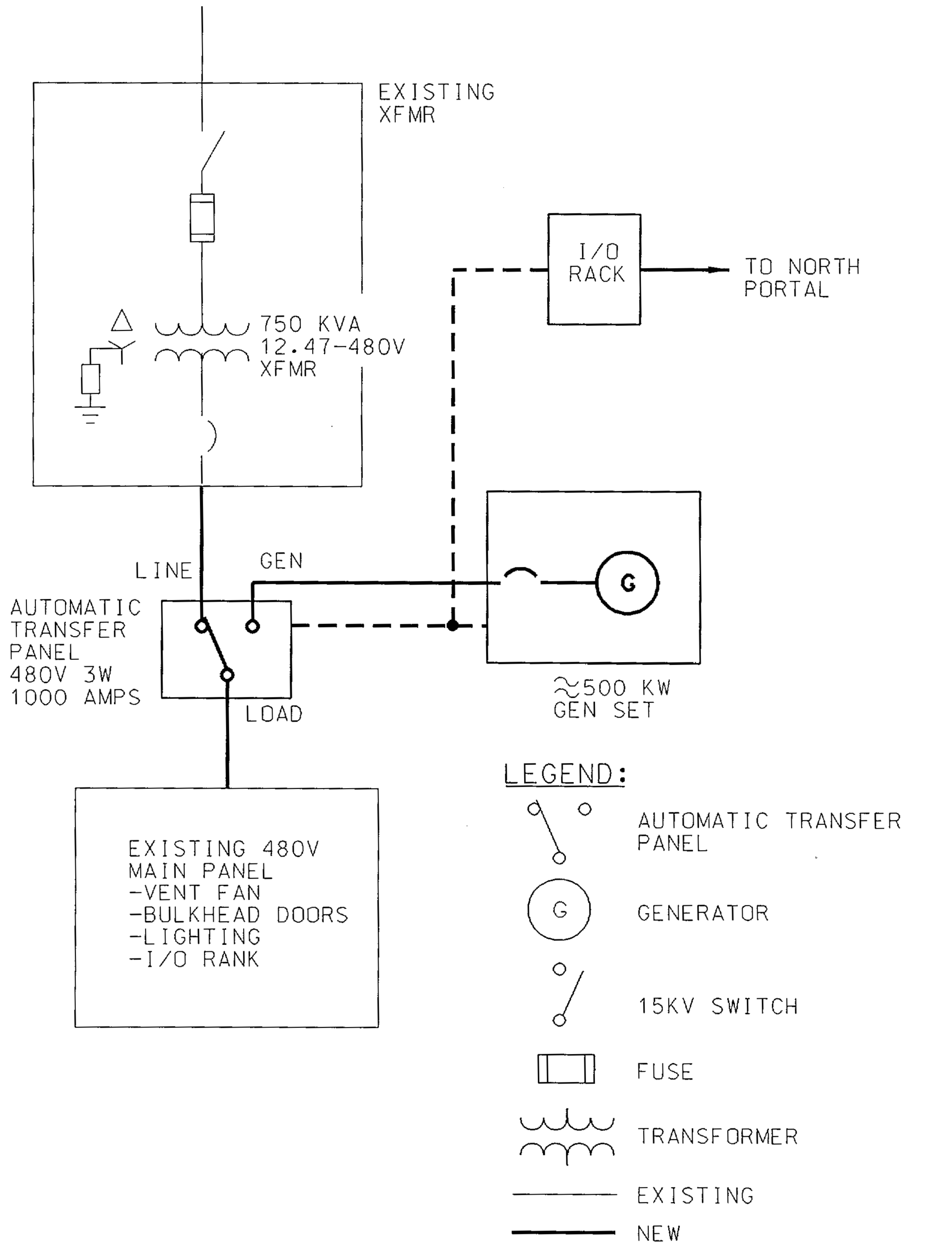


FIGURE 2

SOUTH PORTAL
STANDBY POWER SYSTEM
ONE LINE DIAGRAM

8. CONCLUSIONS

This analysis should be used as a guide for the final design of the standby generator systems at the North and South Portals. Critical Test and Operational activities and ESFDR requirements were addressed by this analysis and preliminary electrical one line diagrams were developed for a viable system.

Key points of a viable Standby Generator Systems for The North and South Portals are listed below:

- As a minimum the following critical loads shall be connected to the standby generating system:

Alcove 5 Vent Fan #1	Alcove 5 Vent Fan #2	Alcove 5 DAS Units
Alcove 5 DAS Units AC	Alcove 5 Fire Detection	Alcove 5 PC's
Alcove 5 Network Server	Alcove 5 mini DAS Units	North Portal PLC
Alcove 5 Office	Alcove 5 Office AC	Alcove 5 CRTS niche
North Portal Walker Shack	Testing Misc. Loads	Flow Through Vent Fan
North Portal DAS Trailer		

- The following documents/sections, as a minimum, needs to be incorporated in Standby generator systems final design:

    - NFPA 70 Chapters 1, 2, 3, 4, 6, 7 , 8 and 9
    - NFPA 110 Chapters 1, 2, 3, 4, 5 and 6
    - IEEE Std. 446
    - DOE Order 6430.1A Division 16
    - 29 CFR 1910 Subpart "S"
    - 29 CFR 1926 Subpart "K" and "S" (For Construction Areas)

  The order of precedence for conflicting requirements of the above documents shall be as listed in the ESFDR paragraph 3.2.1.1.1.B.

- The final design of the generator system shall include generators, fuel supplies, necessary fuel piping, conduit and wire, cutouts, concrete work, and weatherproof enclosures.

- Time delay hardware is needed.

- M&O Environmental Department shall be apprised on the sizes, uses and locations of the standby generators to updated Air Quality and General discharge permits.

- A minimum of 10 percent excess capacity will be incorporated in the standby generator systems.

- The standby power system will be standard, commercially available, industrial grade electrical equipment with a proven record of reliability, durability and safety. This equipment is built in accordance with NEMA standards for industrial equipments. Additionally, the equipment will be installed in areas where maintenance can be easily performed.

- Surplus government equipment shall be considered for filling the requirements of the ESF facilities.

- IEEE Std. 518 Shall be used for minimum distance separation of data and communication wiring form power wiring.

- The standby power system shall incorporate the following environmental conditions.
  -Seismic Condition: UBC Zone 3
  -Equipment shall withstand and operate in
    -sand and wind blown dust
    -temperatures ranging from -14 °F to a high of 108 °F
    -relative humidity environment of 13 to 71%
    -75 mph prevailing winds with maximum gusts up to 97 mph
    -daily precipitation levels of 2.18 inches within 24 hour period

- The below IEEE std. 446 recommendations should be used in the design of standby generators:
  -Voltage Regulation, Steady State: ± 5%
  -Frequency Regulation: ± 0.5 to 0.25 % for isochronous governor
  -Generator Heaters for starting within 10 seconds
  -Derating Factors: Elevation: 4 % per 1000 Ft above 3000 Ft Elevation
  -Temperature: 1% for each 10 °F above 60 °F
  -Voltage Dip on Starting: 30 %
  -Battery Charger
  -Battery Powered Starters
  -Radiator Cooling
  -Generator Protection: Short Circuit & Ground Fault

- Common generator accessories should be considered in the design of standby generator systems:

  -Voltage: Three Phase 480/277 Volts 60 Hz -Main Circuit Breaker
  -AC Entrance Box - Batteries
  -Battery Charger, Equalizer, Float-type -Spring Isolators
  -Weather-Protective Enclosure -Ground Fault Alarm
  -Residential Grade Exhaust System Silencer -Heavy Duty Air Cleaner
  -Space Heater
  -24 Hours (Minimum) Double Wall Sub-base Tank with Leak Detection System
  -480 Volt Coolant Heater (Thermostat Controlled)
  -Control Panel:

-Run-Off-Auto Selector Switch
-Emergency Stop Switch
-Remote Starting Capabilities
-Panel Lighting
-Digital Display
-Generator Monitoring: Oil Temperature, Oil Pressure, Coolant Temperature, RPM, Running Hours

-Metering: Amp, Volt, Kilowatts & Frequency Meters
-Adjustments: Time Start Delay, Time Delay Stop, voltage, frequency, Automatic Voltage Regulation, and Governor Gain
-Shutdown Functions (Failure): Low Oil Pressure, Over-speed, High Coolant Temperature, Fail to Crank, Over-crank
-AC Alternator Shutdowns: Low AC voltage, High AC voltage, Under-frequency, Over Current, Short Circuit, Emergency Stop
-Warning Functions (Pre-Shutdown): Low Oil Pressure, High Coolant Temperature, Over Current, Low Coolant Temperature, Low Fuel, Low DC Voltage, High DC voltage, Weak Battery
-Output Contacts (Customer Connections): Common Alarm Relays, Load Shed Relay, Ready to Load Relay, NFPA 110 Alarm Contact, Three Auxiliary Run Relays

- The addition of transfer and distribution panels and control interlocks will be necessary to integrate the North and South Portal Generator Systems into the existing ESF subsurface distribution system.

9. ATTACHMENTS

ATTACHMENT	DATE	DESCRIPTION
I	1/21/98	North Portal Caterpillar EPG Gen. Sizing Report
II	1/21/98	South Portal Caterpillar EPG Gen. Sizing Report
III	1/22/98	Supporting Material

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SPECIAL INSTRUCTION SHEET

1. QA: N/A

Complete Only Applicable Items

This is a placeholder page for records that cannot be scanned or microfilmed

2. Record Date 1/21/98	3. Accession Number ATT-TO MOL.19981111.0002
4. Author Name(s) N/A	5. Author Organization CATERPILLAR, RELIANCE ELECTRIC

6. Title
CATERPILLAR 3306 DIESEL GENERATOR SET STANBY POWER - 1800 RPM, RELIANCE ELECTRIC AC MOTOR PERFORMANCE DATA (C)

7. Document Number(s) BABFAA000-01717-0200-00005	8. Version REVISION 00
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